

## Multiple Bioelectric Impedance Vectors in the Monitoring of Congestive Heart Failure

I was delighted to read the report by Khoury et al. (1) in the March 24, 2009, issue of the *Journal*, related to an area I have been interested in since 1998, namely, using electrocardiography in monitoring the edematous state of patients with varying pathologic features, including congestive heart failure (CHF) (2). The authors evaluated the response of 6 bioelectric impedance signals in 15 dogs with CHF due to cardiomyopathy imparted by chronic rapid right ventricular pacing by using a variety of electrode configurations of a cardiac resynchronization system that they had implanted. The key finding of this study is that the left ventricular ring-to-can vector represented the electrode configuration with the fastest and largest change in impedance and had the best correlation with the rise in the left ventricular end-diastolic dimension and left atrial pressure noted with the worsening of CHF. The clinical implications here are that a left ventricular lead, in contrast to a right ventricular lead currently used, has advantages in the ambulatory monitoring of CHF. Particularly worrisome is the previously described moderate rate of false positive results of decreasing impedance, measured via the right ventricular lead, in patients who did not have hemodynamic deterioration leading to lung congestion. What I do not understand is why, despite this, the authors urge the use of measurements and monitoring of impedance through multiple electrode configurations, *instead of only using the left ring-to-can electrode*, which they found themselves to be superior to any of the other 5 electrode configurations. What is the objective of such a recommendation? Do they imply that their results need confirmation by other animal investigations, or that their findings require corroboration in human studies, or that they still suspect that the other 5 electrode configurations may have some special role to play? And if the latter is the case, what role?

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### REFERENCES

1. Khoury DS, Naware M, Siou J, et al. Ambulatory monitoring of congestive heart failure by multiple bioelectric impedance vectors. *J Am Coll Cardiol* 2009;53:1075–81.
2. Lumlertgul S, Chenthanakij B, Madias JE. ECG leads I and II to evaluate diuresis of patients with congestive heart failure admitted to the hospital via the emergency department. *Pacing Clin Electrophysiol* 2009;32:64–71.

### Reply

We thank Dr. Madias both for his support of the study findings (1) and for his endorsement of the clinical relevance. Reliable monitoring of heart failure depends on both the sensor technology and the detection algorithm. The study focused on the former subject, namely, measuring impedance via lead sensors readily available in implanted cardiac resynchronization therapy systems. Although impedance measured in between the left ventricular (LV) lead and the Can yielded the largest and fastest change during heart failure in comparison with only right-side heart electrodes, other impedance vectors using the LV lead also were associated with variable but favorable trends. The study was not designed to determine an optimal detection algorithm on the basis of impedance measurements in part because of limitations of the animal model itself. Therefore, it is premature to conclude with certainty that one lead configuration (i.e., LV-Can) is superior to 1 or more combinations of impedance vectors for monitoring heart failure in patients. Clinical trials will be necessary to address this issue. Several factors could impact trends in impedance measured via different electrode configurations that include: 1) heart and torso anatomy and mass; 2) lead electrode location; 3) type and cause of heart failure; 4) concomitant pharmacologic therapy; 5) pulmonary disease; 6) subcutaneous edema; and 7) skeletal muscle resistivity. Given its scope, the study did not advocate using multiple impedance vectors over a single LV-Can configuration, but rather, speculated on possible benefits of using more than 1 vector for sensing, especially when considering the above foreseeable confounding factors in real-life scenarios. This could be particularly attractive when no additional hardware is required and when the platform circuitry of the implanted system affords monitoring multiple impedance parameters.

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